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FUTURE DEVELOPMENTS IN SANITARY ENGINEERING

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FUTURE DEVELOPMENTS IN SANITARY ENGINEERING*

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A review of past achievements is a most essential aspect of this occasion of the Centennial Anniversary of the American Society of Civil Engineers--an important milestone in the progress of engineering in America. The engineering profession has never striven to be known for its prophecies nor for its skill with the crystal ball in evaluating the future; yet, by force of circumstance, the practice of engineering requires a look into the future so that engineering works will serve the requirements of communities for half a century or more. The consequent need for a basis for estimating future developments, for judging what of the past will grow and develop and what will wither under the rigorous demands of the future, must inevitably lead the engineer to review what has gone before.

Scarcely seventy-five years have elapsed since civil engineers who were dealing with community water supply and waste disposal first acquired the knowledge that the causative agents of enteric diseases such as cholera and typhoid were often present in sewage and that water-borne diseases could be controlled by engineering works and techniques; but during the period which began three quarters of a century ago in the State of Massachusetts a new field of engineering has developed--sanitary engineering, which has been America's gift to the world.

Throughout the years it became increasingly apparent that scientific disciplines such as chemistry, bacteriology, and epidemiology, not normally associated with civil engineering, were essential to the conquering of diseases transmitted through water. Sanitary engineers found it necessary not only to cooperate closely with chemists, biologists, and physicians in accomplishing sanitation, but also to incorporate certain aspects of these disciplines into their own education. Research in chemistry and biology provided important tools which the sanitary engineer has put to use in controlling the spread of disease.

From an early concern with safe water supplies and good methods of waste disposal, sanitary engineers have become concerned with many other environmental factors which render the members of society less useful by reason of lowered health or premature death, or less happy by reason of unnecessarily constrained living. To a considerable degree sanitary engineers' activities have been centered in public health organizations in which their leadership in the control of man's environment and their cooperation with other professions dealing with health problems has led to an outstanding record of accomplishment in communicable disease control. Viewed in retrospect, it seems possible that never in history has so much been accomplished by so few as the small group of sanitary engineers during the last half century.

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In the year 1900 typhoid fever took 31.3 lives per 100,000 people per year, while the annual death rate of children under two years old due to diarrhea and enteritis was 115.9. These diseases, which were among the leading causes of death, are now relatively insignificant: 0.1 for typhoid fever and 1.3 for infant diarrhea. There has been no cholera in the United States during the last half century, and no yellow fever in almost as long. Hookworm, formerly prevalent in many areas, has practically disappeared. Malaria, the number one disease in the world, was once common in the southern states and was found as far north as Iowa, Michigan, and New York. Today in the United States it has become difficult to find cases even in the areas which were most heavily infected a few years ago.

This great reduction in the incidence of diseases transmitted through man's environment has been to a great extent the result of the sanitary engineers' efforts in developing safe water supplies, in sanitary disposal of excrement, and in controlling insect vectors of disease. The diseases which are known to be controllable by engineering activities have been reduced to a very low level, and one might assume that the sanitary engineer could soon be expected to fade out of the public health picture. Such, however, is not the case, for while the incidence of most diseases which can be controlled by sanitation has approached zero, some other sanitary conditions are at present worse than they were 50 to 100 years ago. Most notable is the pollution of our water courses by human and industrial wastes. There is scarcely a city in the United States in which atmospheric pollution conditions are not worse than they were a century ago. There are still about 6000 communities in the United States without public water supply and over 9000 communities need sewerage systems. Garbage collection and disposal systems in most communities are much in need of improvement. In addition, changes in environment for the purpose of effecting disease control have made for more satisfactory living, and the sanitary engineer is now expected not only to deal with matters of disease prevention but also to control nuisances which detract from the comforts of the environment.

The growth of urban and suburban areas, industrialization and congestion of cities, increased travel with respect to both distance and time, and changing living conditions have all increased the need for sanitation. The cost of providing sanitation has increased as well. In fact, so much remains to be discovered concerning the principles of sanitary engineering processes and methods we are now using, and in developing more economical methods, that throughout the foreseeable future we may expect the sanitary engineer to be increasingly busy at everything from research at home to education abroad.

Research

Research in sanitary engineering is destined to be a more important factor in sanitary accomplishments in the future than in the past. Sanitary engineering progress during the past three quarters of a century, however rapid it may appear in retrospect, depended largely upon the accumulation of experience in the operation of treatment works, reinforced by experimentation, mostly of an applied nature. As a result out knowledge of the fundamental principles of many aspects of sanitary engineering as practiced today is extremely circumscribed. In the field of industrial waste treatment, for example, time honored procedures are often too uneconomical or inadequate to achieve the standards of sanitation we have come to demand. Consequently we may expect future sanitary engineering research to become increasingly concerned with fundamentals, although applied research will continue to contribute greatly to

sanitary progress. It is inevitable that in the future, as in the past, the sanitary engineer faced with a new problem will develop a workable and economic method before he has had time to learn all of the fundamental details which later will be studied in using and improving the method. Future research may be expected to deal with

1. Fundamental principles of processes and methods now in use, in order that we may better understand them and apply them more economically.
2. The development of new analytical methods, new tools, and new techniques which will enable us to break through the horizon of our knowledge and open up completely new approaches to sanitary problems.
3. Applied and developmental research.

The spectacular decrease in the incidence of diseases controllable by sanitary engineering indicates that relatively less research effort will be devoted to that area in the future. There will be sanitary developments related to either new diseases or old ones brought into the sanitary field by new information. For example, infectious hepatitis, dental fluorosis, and methemoglobinemia, are of more or less recent interest. In the realm of environmental health, research dealing with healthful living in tropical or in arctic regions, and survival at high and low pressures will receive great attention. New developments in our industrial methods will require continuing research dealing with the adaption of the machine, and the environment it produces, to man. Unfortunately, sanitary problems growing out of new methods of warfare and the aspects of total war which require sanitary protection of civilian populations may necessitate great research effort.

Important as research directly related to health has been in the past and may still be to sanitary engineering in the future, it appears that it will not be the greatest challenge to sanitary engineers. The greatest challenge seems to lie in a different direction, in the introduction of a new concept into sanitary engineering: the concept of conservation and reclamation.

All aspects of water conservation and of sound planning for maximum utilization of water will receive exhaustive future investigation. Research will supply the missing tools with which sewage, industrial wastes, and even the ocean will be made to return water suitable for reuse as public water supply or by agriculture.

The prospects of developing more feasible methods of reclaiming organic matter and minerals from wastes which sanitary engineers have chosen in the past to dispose of in the easiest manner seem bright for the future. In fact the reclamation of wastes may be accomplished by sanitary engineering research before such research makes possible the reclamation of water. In any event the United States is fast beginning to recognize the needs and possibilities of reclamation of its liquid and solid wastes, and the next 25 years will see great strides in this direction through research of both a fundamental and an applied nature.

It is hardly necessary to mention industrial wastes in connection with future research development. New industries and new industrial process will continuously require extensive research to provide efficient waste disposal. Fortunately, the fundamental research that produces new processes and industries also produces some of the basic knowledge necessary to solve the accompanying waste problems. In addition, these industries often provide new tools which the engineer can apply. For example, new chemicals have been and are being developed which may be of use in sanitary engineering. It will be remembered that DDT was known for many years before its amazing properties as an insecticide were discovered.

Developments in the field of ultrasonics and electromagnetic waves may become important tools to the sanitary engineer. Radioactive materials which now create a disposal problem can also become a tool for solving other sanitary engineering problems. No doubt there are already many developments in the pure sciences which while not recognized at present will be found by someone, either by intent or by chance, to have important application to sanitary engineering.

As in the past, future research in sanitary engineering will be done largely through public support. Research in the fields of water purification, sewage and waste treatment, refuse disposal, air pollution, and other sanitary developments, although much needed economically and for the public health and welfare, has not been attractive to private business because there has not been a market which would support large research investiments. Future research must give heed to ways and means of lowering the cost of providing sanitation.

Sanitary Engineering in Public Health Agencies

The role of the sanitary engineer in public health organizations is changing more rapidly in the United States, the birthplace of modern sanitary engineering, than anywhere else in the world. Among most of the world population sanitary engineering is so much in its infancy that extensive sanitary works must be developed before there can exist a firm foundation for protecting the public health. In the United States, however, the incidence of diseases known to be controllable by sanitary effort is so near a minimum that only small further lowering can be expected.

Although vigilance must be maintained because our population is becoming less and less immune to these diseases, we are at the same time developing more efficient and more widely used barriers to the spread of disease through the environment by water and sewage treatment plants, milk pasteurization, and vector control facilities staffed with trained personnel.

As a result of these developments, the major public health problems confronting the United States today are in medical fields and quite apart from engineering, while the engineer is becoming more concerned with environmental problems such as industrial wastes, water and air pollution, sanitary facilities, public works, and the planning and control of the environment for more comfortable and satisfactory living.

It would appear that the public health team, the physician and engineer, so important in the past, will not be as extensively required in the future. The environmental control activities of health departments will become more closely associated with other aspects of public works endeavor. Possibly in the future the medical and nursing fields of public health will become more closely associated with medical care and welfare programs dealing more directly with the individual, leaving the control and safeguarding of man's environment as a separate, less closely associated function. Greater health education of the public and the development through engineering ingenuity and research of new techniques and methods will have far reaching effects on the incidence of food-borne diseases and should reduce the amount of sanitary inspection required. In addition, present and probable future relationship between interest rates and wages will make it economical to spend larger sums for sanitary and environmental control facilities in order to reduce expenditures for personnel to perform sanitary functions.

While the future pattern cannot be accurately predicted, it does seem obvious that the pattern of the past fifty years is in transition and will not be the

most efficient pattern in the future, and that sanitary engineers will be more closely associated with public works, reclamation, and natural resources. Future sanitary engineering activities in public health will deal with broader planning for the sanitary control of the air, water, food, shelter, vector and other environmental health contacts and less with the pinpoint inspection of some facility.

Air Pollution

Of the three outlets for waste disposal--air, water, and land--air perhaps has received the least attention. The ever increasing size of cities, and the increased use of combustion processes both for power and for disposal of wastes which might otherwise be disposed of on land or in the water have contributed greatly to the problems of atmospheric pollution.

The application of sanitary engineering to the control of air pollution both indoor and outdoor is in its infancy. Excellent progress in ventilation and control of chemical contaminants in enclosed spaces has been made in the recent years, yet the control of respiratory diseases by engineering methods has not been achieved and atmospheric pollution is generally worse than it was fifty years ago. While the economic, aesthetic and hygienic aspects of air pollution will dictate future progress, the prevention of incidents such as occurred in the Meuse Valley and at Donora, and the control of smog which blankets many of our cities, shutting out the sunlight, depriving people of the desirable radiations and lowering the standards of cleanliness, are challenges which will be met during the next few years.

Although there is much to be accomplished in the control of airborne diseases, recent progress indicates that we may expect important future developments in this field. We know how to disinfect air but there is much to be learned about the effects of atmospheric pollution on health, about how diseases are spread through air, and how to make air disinfection more efficient and effective. Micrometeorological studies, a development largely of the last decade, may permit us in the future to place under engineering command the movements of air over cities.

With tools now at hand and new tools and information yet to be developed the engineer will accomplish major changes in conditions of atmospheric pollution in the next quarter century.

Water

The interest of the engineer in safe water led to the development of sanitary engineering and has always been one of his greatest concerns. That it will continue to be among his greatest concerns seems evident, for, as previously mentioned, some 6000 communities are still in need of a public water supply, in spite of the great achievements of the past in providing water to our cities.

Water is now short in many areas and during the next 50 years may cause the most critical of engineering and natural resource problems. We have been successful in using the frest waters of the earth for multiple purposes, but we shall now have to learn to protect them more carefully both as to quality and quantity.

Water needs and uses will continue to increase. The critical lowering of the ground water levels in many areas, with the accompanying intrusion of sea water, calls for an already overdue engineering solution. In the arid portions of the world the conservation and reuse of water is especially important. Thus

sanitary engineering must take the lead in developing water sources and in water reclamation, changing if necessary the entire drainage systems of cities, for these arid regions constitute the only areas which can provide new major sources of food.

Progress in the reclamation of industrial and domestic waste waters is encouraging and indicates that their conservation and reuse will be economically and efficiently accomplished in many places in the not too distant future. Direct reuse of these waters or their storage in local ground water basins will no doubt be accomplished.

Developments in the conversion of sea water into fresh water have been remarkable during the past decade. Compression distillation has become a useful method for obtaining fresh water in some places where the high cost involved could be justified. Other methods may be developed which will make efficient use of solar energy, combustible fuel, or electric power to transform sea water into fresh water, as the theoretical energy (not heat) requirements of such a conversion are only about 3600 KWH per million gallons. The recent development of membranes of selective permeability to anions and cations presents many theoretical possibilities. It seems reasonable to believe that the sanitary engineering of the future will involve much more extensive reclamation of sea water.

In the future the sanitary engineer will no longer consider water supply and water carried waste disposal as two different problems but rather as a single problem of water use--a cycle over which he must exercise complete stewardship. In addition to collecting and transporting water from its source, making it biologically and aesthetically acceptable, distributing it for use and abuse, then collecting and disposing of the secondhand water called sewage, he must also remove the small fraction impurities which caused the change of name so that the water can be used again.

The accomplishments of the sanitary engineer in the field of water supply have been truly great, but the challenge of the future is even greater.

Waste Disposal and Utilization

The need for waste disposal and utilization is great, and the engineering developments in this field are in their infancy. Our streams are more polluted than they were 50 years ago. The National Stream Pollution Act was only recently enacted and the major accomplishments of this program are yet to be achieved. The combined sewers and palliative intercepting sewers of many older communities will have to be changed to effect more efficient and economical sewage treatment. Industrial wastes from organic synthesis, production of antibiotics, and the development of atomic fission bring sanitary engineering problems requiring future solutions. New industrial processes and products with accompanying waste disposal requirements call for continuing sanitary engineering action.

Even in the more conventional fields with which sanitary engineers have been concerned in the past the work is far from completed. Nine thousand communities still need sewerage systems and over 30 million people lack satisfactory excrement disposal facilities. In the matter of municipal refuse collection and disposal, 8000 communities need modern facilities, and in countless others the method used will not meet the sanitary standards or economic requirements of the future. In fact, garbage and other refuse disposal is a major sanitary engineering problem in most cities. Feeding of garbage to hogs has been opposed for both public health and nuisance reasons; land fills

require long expensive hauls in many urban areas; and the future of incineration of organic refuse seems rather limited unless recovery of waste heat, reduction in cost, and the elimination of resulting air pollution can be accomplished. It appears that by 1975 probably 65% to 75% of household garbage will be ground and discharged into the sewer.

In the past the sanitary engineer has given little attention to reclaiming the organic matter and other materials in municipal and industrial wastes. Most of these materials are emptied into rivers, where they pollute the water, burned, with resulting pollution of the air, or thrown into improperly operated fills where they encourage the development of flies and rodents. In any case humus material sorely needed by our land is irretrievably wasted.

Chadwick and Shattuck, disciples of sanitation a century ago, both recommended returning these wastes to the soil but little planned effort to do so has been evident in the past history of the United States, principally because the cost of reclamation could not be justified on an economic basis. Agriculturists today, however, are recognizing that mineral fertilizers without organic humus do not efficiently maintain a highly productive soil and they call attention to the manner in which the practice of using night soil and other organic wastes as fertilizers, in the Orient and elsewhere, has made possible the survival of ancient societies.

The western world, including the United States, is fast beginning to recognize the need for and the possibility of reclaiming the wastes from cities for the organic humus and the trace elements as well as other materials needed for the soil. It is believed that the point of long time profitable returns in preventing soil exhaustion by reclaiming these wastes has been reached.

About two-thirds of the population of the world lives in areas which cannot grow sufficient food to meet its needs. Sanitary engineers are already looking to the possibility of composting of waste organic matter to provide a useful fertilizer and soil conditioner as a solution to the disturbing problem of waste disposal and thus at the same time enable agricultural lands adjacent to large population concentrations to maintain the needed high production of certain foods.

The use of algae and other chlorophyl producing plants as a source of oxygen for bacteria in the removal and stabilization of waste materials from sewage and industrial wastes has been successful in areas of moderate climate. It is highly possible that algae can be grown in sewage to provide oxygen and accelerate treatment, and that the algae can be harvested and used as a source of protein, food and material for industrial processing.

Insects and Rodents

The impact of the application of engineering methods to the environmental control of insect-borne diseases during the last three decades has been most significant in the United States where malaria has been practically eliminated, yellow fever and European typhus have been eliminated, and other insect-borne diseases have been held at a very low level. Insecticides have contributed greatly to this control but vigilance, good sanitary housekeeping in our environment, and engineering in the elimination of breeding places will continue to be necessary. Engineering "know how" will always be required to eliminate "man made" breeding places and provide the quality of housekeeping necessary to maintain an environment free from insect-borne diseases and relatively free from pest insects.

On a world-wide basis the control of the pestilential diseases has barely begun. Perhaps these diseases, particularly malaria, have greater impact than

anything else on the health, working capacity, and economic conditions of a large portion of the peoples of the world.

There are excellent opportunities to introduce the engineering techniques of insect control into the less developed areas of the world. This field presents a challenge to sanitary engineers for future accomplishments greater than those of the past. But here in the United States the future activities in insect control do not now hold their former challenge.

In the matter of rodents, there should be a lessening of sanitary engineering effort devoted to rodent control problems because of improved methods of handling and disposing of refuse, advancing sanitary standards, the reclamation of waste materials by composting or discharge into sewers, rodent proof construction, and health education of the public. As in the case of insects, however, engineering vigilance will be necessary to keep the environment relatively free from rodents and the associated nuisance and threat to the public health.

Food and Milk Control

Unsanitary milk and other foods still account for a number of disease outbreaks each year. Future reductions in the incidence of these outbreaks will be most efficiently accomplished through public health education and engineering research leading to the development of more adequate facilities and methods for producing, handling, storing, preparing and serving foods, that better safeguard them from contamination. Future opportunities for the engineer in this field will pertain to ingenious design and planning. Education of the public and food handlers will prove to be much more effective than extensive sanitary inspection.

Housing

Healthful and adequate housing remains a challenge to future engineering ingenuity and research. Over sixty per cent of the farmhouses in the United States lack running water and only twenty per cent have bath and toilet facilities. The needed sanitary improvements will be accomplished largely by education, through the improvement of economic conditions and through research.

Greatly improved methods of heating dwellings (possibly solar energy), better methods for lighting and ventilation, insulation against noise, as well as new materials and designs permitting easier maintenance of a hygienic environment in the house may well become widely used in the not distant future.

While healthful housing will remain a concern of the sanitary engineer, the future role of the practicing sanitary in the field of housing will be limited, and his direct engineering activity in the field will be largely in the area of environmental planning.

Education

Sanitary engineering instruction beyond the elementary aspects of sewerage and water supply design has gradually been developed in over twenty-five institutions in the United States. This instruction has been mainly in the undergraduate program in civil engineering and often with little emphasis on the chemistry and biology, which are important in the education of a sanitary engineer. Sanitary Engineering will continue to be associated with the civil

engineering but the emphasis on chemistry and biology will be increased.

For sanitary engineering the traditional four years engineering program will give way to a five to six year program of which at least three years will be devoted to fundamental engineering sciences and the remainder to chemistry, biology, hygiene and professional engineering studies. Some of the chemistry and biology and most of the professional studies will be taken in the fifth and sixth years. The scope and variety of the activities associated with the engineering control of man's environment indicate that the sanitary engineer must have a broad education. There will also be increasing need for sanitary engineers who are well grounded in fundamental sciences.

Sanitary engineering education will be programmed to meet two types of needs: for the highly scientific and technical specialist in some aspect of the field; for the engineer who has had good basic fundamental training and whose education and experience are sufficiently broad to qualify him for planning and administration of sanitary engineering developments. In other words, future sanitary engineers will bring to their activities greater education in the basic sciences, the professional endeavors, and in public administration.

International Development

During the next twenty-five years many sanitary engineers will practice their profession in the vast areas of the world which have yet to grasp the benefits of sanitation. As has been said, sanitary engineering is America's gift to the world. The economic and satisfactory development of the backward areas of this globe is dependent to a considerable degree on sanitation. The international developments of the Rockefeller Foundation and the Institute of Inter-American Affairs and the more recently established World Health Organization have depended greatly on the foundation of sanitation. If the so-called "Point 4" program and other programs aimed at raising the economic levels of backward areas, promoting democracy, and reducing communism are to be successful, sanitary engineering for the control of killing and debilating diseases and the eventual eradication of their cause or causative organisms is necessary. The eradication of cholera and yellow fever in the United States is evidence of what can be done in other areas.

In a world in which the speed of modern transporationt has eliminated the time barrier to the transmission of communicable disease, global sanitary engineering activities to control and eradicate these menaces is necessary. Sanitation under the leadership of sanitation engineering will be one of the most important foundation stones in the drive to develop human and economic resources of backward areas and to strengthen the concepts of democracy.

If we look again at the past seventy-five years we see the remarkable contribution of the sanitary engineer to the reduction in those weeds in the garden of humanity--the communicable diseases--and to improving man's environment. The future challenge for improving sanitary conditions in our environment at home, for bringing sanitary "know how" to vast areas of the globe where the people are killed or debilated by malaria and other diseases controllable by engineering efforts, and for pushing back the horizons of our knowledge of sanitary engineering via the avenues of research, education and practice is even greater than that visualized seventy-five years ago. In addition future sanitary engineering activities will include the further challenge and opportunity to contribute to the conservation of our resources by reclaiming and salvaging public and industrial wastes.